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Healing of intrabony peri-implantitis defects following application of a nanocrystalline hydroxyapatite (Ostim™) or a bovine-derived xenograft (Bio-Oss™) in combination with a collagen membrane (Bio-Gide™). A case series

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Abstract

Objectives: The aim of the present case series was to evaluate the healing of intrabony peri-implantitis defects following application of a nanocrystalline hydroxyapatite (NHA) or a bovine-derived xenograft in combination with a collagen membrane (BDX+BG).

Material and Methods: Twenty-two patients having moderate peri-implantitis ($n = 22$ intrabony defects) were randomly treated with (i) access flap surgery (AFS) and the application of NHA, or with AFS and the application of BDX+BG. Clinical parameters were recorded at baseline and after 6 months of non-submerged healing.

Results: Post-operative wound healing revealed that NHA compromized initial adhesion of the mucoperiosteal flaps in all patients. At 6 months after therapy, NHA showed a reduction in the mean PD from 7.0 ± 0.6 to 4.9 ± 0.6 mm and a change in the mean clinical attachment loss (CAL) from 7.5 ± 0.8 to 5.7 ± 1.0 mm. In the BDX+BC group, the mean PD was reduced from 7.1 ± 0.8 to 4.5 ± 0.7 mm and the mean CAL changed from 7.5 ± 1.0 to 5.2 ± 0.8 mm.

Conclusion: Within the limits of the present case series, it can be concluded that at 6 months after surgery both therapies resulted in clinically important PD reductions and CAL gains.

Key words: bone graft; clinical study; collagen membrane; non-submerged healing; peri-implantitis

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Nowadays, the term peri-implant disease is collectively used to describe biological complications in implant dentistry including peri-implant mucositis and peri-implantitis. While peri-implant mucositis includes reversible inflammatory reactions located solely in the mucosa adjacent to an implant, peri-implantitis was defined as an inflammatory process that affects all tissues around an osseointegrated implant in function, resulting in a loss of the sup-

porting alveolar bone (Albrektsson & Isidor 1994). The prevalence of peri-implantitis is difficult to estimate as the determination of criteria for implant success is not uniform (Albrektsson et al. 1986, Buser et al. 1990, van Steenberghe 1997). However, considering the clinical and radiological threshold parameters assessed at different implant designs, it may vary between 10% and 29% (Brägger et al. 1996, Buser et al. 1997, Karoussis et al. 2003, 2004). Today, there is considerable evidence supporting the view that microbial colonization plays a major role in the aetiology of peri-implant infections (Mombelli et al. 1988, Becker et al. 1990, Alcoforado et al. 1991). Even though bone resorption in peri-implantitis defects may also be intensified by occlusal overload (Isidor 1996, 1997), it was assumed that the removal of bacterial plaque biofilms from the implant surface seems to be a pre-requisite in order to stop disease progression. Accordingly, several conventional treatment approaches including plastic curettes, sonic/ultrasonic scalers and air-powder flow have been recommended for the debridement of contaminated implant surfaces (Fox et al. 1990, Rühling et al. 1994, Matarasso et al. 1996, Augthun et al. 1998). However, as mechanical methods alone have been proven to be insufficient in the elimination of plaque biofilms and bacteria on roughened implant surfaces (Kreisler et al. 2005, Schwarz et al. 2006a), the adjunctive use of chemical agents (i.e. irrigation with local disinfectants, local or systemic antibiotic therapy) (Mombelli & Lang 1992, Ericsson et al. 1996, Schenk et al. 1997) and different laser systems (Deppe et al. 2001, Schwarz et al. 2005) has been recommended in order to enhance healing following treatment. In addition to these conventional tools, regenerative treatment procedures have been advocated for the restoration of the implant-supporting tissues (Ericsson et al. 1996, Persson et al. 1996, Hürzeler et al. 1997, Nociti et al. 2001b, Schou et al. 2003a–c, 2004). Most of these studies used the concept of guided bone regeneration (GBR), which involves the placement of a barrier membrane to protect the blood clot and create a secluded space around the bone defect, enabling bone regeneration without competition from other tissues (Dahlin et al. 1988). In recent years, a variety of different membrane materials have been successfully used for GBR procedures, ranging from non-resorbable materials such as expanded polytetrafluorethylene (e-PTFE) to bioabsorbable membranes composed of dura-mater, polylactic acid, polyglycolic acid and polyurethane (Magnusson et al. 1988, Greenstein & Caton 1993, Hutmacher et al. 1996, Kohal et al. 1998). Most recently, many investigations have focused on the use of products derived from type I and type III porcine or bovine collagen (for a review, see Bunyaratavej & Wang 2001). Some advantageous properties of collagen over other materials include haemostatic function, allowing an early wound stabilization, chemotactic properties to attract fibroblasts and, semipermeability, facilitating nutrient transfer (Postlethwaite et al. 1978, Yaffe et al. 1984, Schwarz et al. 2006b). However, a major drawback of native collagen is the fast biodegradation by the enzymatic activity of macrophages, polymorphonuclear leucocytes and periodontopathic bacteria, resulting in a poor membrane resistance to collapse, allowing undesirable cell types to enter the secluded wound area (Tatakis et al. 1999, Sela et al. 2003, Rothamel et al. 2005). However, the collapse may be prevented by means of implantation of bone grafts or bone graft substitutes into the defect to support the membrane, preserving its original position. Preliminary experimental studies have shown that nanosized ceramics may represent a promising class of bone graft substitutes due to their improved osseointegrative properties (Webster et al. 2000, Chris Arts et al. 2006). Accordingly, a ready-to-use paste in a syringe, available under the name Ostim™ (Heraeus Kulzer, Hanau, Germany) (NHA), containing about 65% water and nanoscopic apatite particles (35%) in aqueous dispersion, has recently been recommended for augmentation procedures in osseous defects (Moghadam et al. 2004, Thorwarth et al. 2005). In particular, experimental animal studies have pointed to an indisturbed ossoeous-integration and complete resorption of the material within 12 weeks (Thorwarth et al. 2005, Chris Arts et al. 2006). Owing to its specific physicochemical properties, NHA is intended to be used without the additional application of a barrier membrane. So far, however, there are no data from controlled clinical studies evaluating the healing of peri-implantitis lesions following treatment with NHA. Therefore, the aim of this case series was to evaluate and compare the healing of moderate intrabony peri-implantitis defects following treatment with access flap surgery (AFS) and the application of NHA or a bovine-derived xenograft in combination with a collagen membrane.

Materials and Methods

Study population

Twenty-two partially edentulous patients having moderate peri-implantitis (Mombelli & Lang 1994) attending the Department of Oral Surgery, Heinrich Heine University, Düsseldorf, Germany, for peri-implant bone augmentation procedures were included in this parallel-design case series (i.e. 11 patients in each group). Each patient was given a detailed description of the procedure and was required to sign an informed consent before participation. The study was in accordance with the Helsinki Declaration of 1975, as revised in 2000, and all participants signed informed consent forms. The study protocol was approved by the ethical committee of the Heinrich Heine University.

The patient population consisted of eight men and 14 women (mean age 54.4 ± 12.5 years), exhibiting a total of $n = 22$ implants. Patients reporting to smoke only occasionally were not considered as smokers (Tonetti et al. 1995). According to the given definition, there were no smokers included in the present study. All patients had been previously treated by a single course of non-surgical instrumentation of respective titanium implants using plastic curettes (Straumann, Waldenburg, Switzerland), followed by pocket irrigation with a 0.2% chlorhexidine digluconate solution (Corsodyl®, GlaxoSmithKline Consumer Healthcare, Bühl, Germany) (CHX) and subgingival application of CHX gel 0.2% (Corsodyl® Gel, GlaxoSmithKline Consumer Healthcare, Bühl, Germany). The criteria needed for inclusion were as follows: (1) the presence of at least one screw-type implant exhibiting an intrabony defect with a probing depth (PD) of >6 mm and an intrabony component of >3 mm as detected on radiographs, (2) no implant mobility, (3) single tooth and bridgework restaurations without overhangings or margins, (4) no evidence of occlusal overload, (5) the presence of keratinized peri-implant mucosa, (6) no signs of acute periodontitis, (7) a good level of oral hygiene [plaque index (PI) <1 (Löe 1967)] and (8) no systemic diseases that could influence the out-

Table 1. Distribution and mean age (years ± SD) of different implant systems in both groups

Group	BRA	CAM	ITI	KSI	MTX	TSV	ZL	Age
Test ($n = 11$)	1	1	2	1	4	1	1	3.6 ± 1.9
Control ($n = 11$)	1	1	2	1	3	2	1	4.0 ± 0.9

BRA Brånemark System®, Nobel Biocare, Göteborg, Sweden.
CAM Camlog Screw Line®, Camlog, Wimsheim, Germany.
ITI ITI (SLA, TPS)®, Straumann, Waldenburg, Switzerland.
KSI KSI Bauer Schraube®, KSI Bauer Schraube GmbH, Bad Nauheim, Germany.
MTX Spline Twist (MTX)®, Zimmer Dental, Freiburg, Germany.
TSV Tapered Screw Vent®, Zimmer Dental, Freiburg, Germany.
ZL ZL-Duraplant (Ticer)®, ZL Microdent, Breckerfeld, Germany.

Table 2. Position of implants in both groups

Group	Upper jaw		Lower jaw	
	anterior	posterior	anterior	posterior
Test ($n = 11$)	2	4	0	5
Control ($n = 11$)	1	5	0	5

come of the therapy (i.e. diabetes, osteoporosis).

Hollow cylinder implants were excluded from the study. The distribution, mean age and position of different implant systems in both groups are presented in Tables 1 and 2.

Clinical measurements

The following clinical parameters were measured immediately before, and 6 months after treatment using a periodontal probe (PCP 12, Hu-Friedy): (1) PI (Löe 1967), (2) bleeding on probing (BOP), evaluated as present if bleeding was evident within 30 s after probing, or absent, if no bleeding was noticed within 30 s after probing, (3) PD measured from the mucosal margin to the bottom of the probeable pocket, (4) gingival recession (GR) measured from the implant neck (IN) to the mucosal margin and (5) clinical attachment level (CAL) measured from IN to the bottom of the probeable pocket. The primary outcome variable was CAL. All measurements were made at six aspects per implant: mesiovestibular (mv), midvestibular (v), distovestibular (dv), mesiooral (mo), midoral (o) and distooral (do) by one blinded and previously calibrated investigator (K.B.).

Pre- and post-operative radiographs were taken with the long cone paralleling technique and evaluated by one blinded investigator (K.B.).

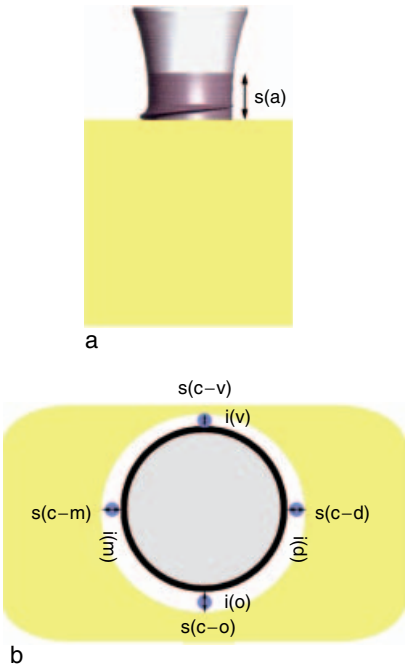

Fig. 1. Configuration assessment of peri-implant bone defects. (a) Supra-alveolar component – s(a): measured as maximum linear mesial or distal (m,d) distance from bony and transmucosal part to the alveolar bone crest. (b) Semi-/circumferential component – s(c): measured as the linear distance from the vestibular – s(c-v), mesial – s(c-m), distal – s(c-d) and oral – s(c-o) bone wall of the defect to the implant surface Intrabony component – i: measured as the linear distance from the alveolar bone crest to the bottom of the defect (v, m, d, o).

Configuration assessment of peri-implant bone defects

During open flap surgery, the following measurements (Fig. 1) were made by one blinded and previously calibrated investigator (K.B.):

1. supra-alveolar component – s(a) of the defect, measured as maximum linear mesial or distal distance from the borderline between the bony and transmucosal part (BTB) of the implant to the alveolar bone crest,
2. circumferential component – s(c) of the defect, measured as the linear distance from the vestibular – s(c-v), mesial – s(c-m), distal – s(c-d) and oral – s(c-o) bone wall of the defect to the implant surface and
3. intrabony component of the defect, measured as the linear distance from the alveolar bone crest to the bottom of the defect (v, m, d, o).

Intra-examiner reproducibility

Five patients, each showing two implants with PDs $\geqslant 4$ mm on at least one aspect, were used to calibrate the examiner. The examiner evaluated the patients on two separate occasions, 48 h apart. Calibration was accepted if measurements at baseline and at 48 h were within a millimetre at $>90\%$ of the time.

Randomization procedure

The defects were randomly assigned before surgery to the following test and control groups according to a computer-generated protocol (RandList®, DatInf GmbH, Tübingen, Germany): (i) AFS and the application of NHA (test), or (ii) AFS and the application of a bovine-derived xenograft in combination with a collagen membrane (control). For allowing randomization, supra- and intra-bony components were estimated before surgery on radiographs and by performing transgingival bone sounding. The randomization process led to comparable mean values of all investigated clinical parameters at baseline in both groups.

Treatments

All operative procedures were performed under local anaesthesia by the same surgeon (F.S.). Following intracrevicular incisions, full-thickness mucoperiosteal flaps were raised vestibularly and orally. Vertical releasing incisions were performed only if necessary for a better access or to achieve a better closure of the surgical site. All granulation tissue was removed from the defects and the implant surfaces were thoroughly debrided using plastic curettes (Straumann® Dental Implant System,

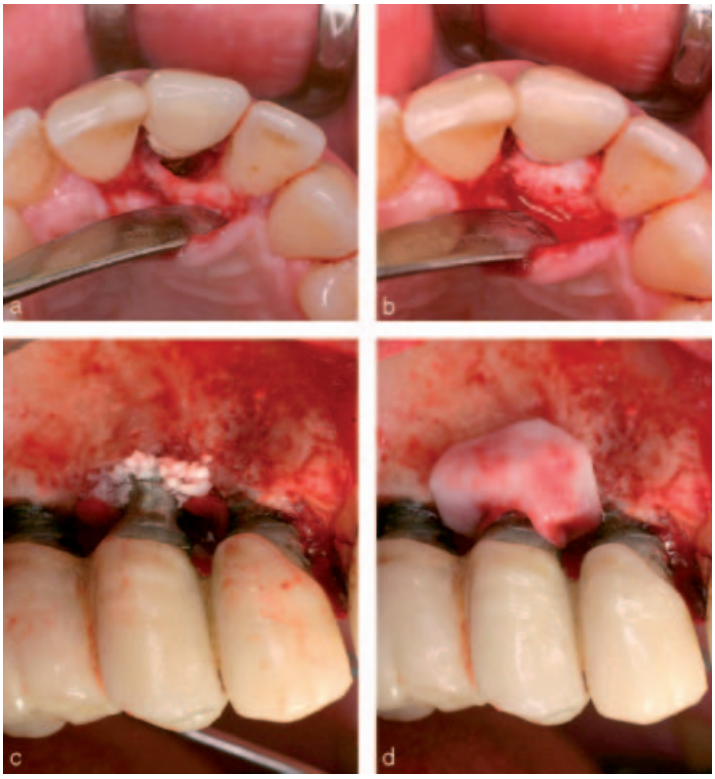

Fig. 2. (a) Semi-circumferential intrabony defect. (b) Situation following application of nanocrystalline hydroxyapatite. (c) Situation following application of bovine-derived xenograft in the circumferential bone defect. BG was trimmed and adapted over the oral and (d) the vestibular aspect of the defect.

Table 3. Baseline defect characteristics in mm (mean ± SD)

Treatment	s(a)	s(c)	i	semi-circular	circular
Test ($n = 11$)	1.8 ± 0.9	2.5 ± 0.5	4.4 ± 0.5	2	9
Control ($n = 11$)	1.5 ± 0.5	2.4 ± 0.7	4.3 ± 0.6	3	8

Straumann AG, Basel, Switzerland). Following cleaning, the exposed implant and bony surfaces were rinsed with sterile physiologic saline.

At the test sites, bleeding into the defects was reduced to a minimum and they were subsequently filled with NHA, starting from the bottom of the defect. Care was taken to obtain a direct contact between NHA and the adjacent alveolar bone, without interposition of a blood clot. Defects were slightly overfilled, as NHA has a creamy consistence and tends to leak from the defect.

At the control sites, the defects were filled with a bovine-derived xenograft (BioOss® spongiosa granules, particle size 0.25–1 mm, Geistlich, Wolhusen, Switzerland) (BDX). The graft material was moistened in sterile saline for 5 min. before placement into the defect. Following grafting, a bioresorbable collagen membrane of porcine origin (BioGide®, Geistlich) (BG) was trimmed and adapted over the entire defect so as to cover 2–3 mm of the surrounding alveolar bone and to ensure stability of the graft material. Neither sutures nor pins were used for membrane fixation or stabilization (Fig. 2).

Finally, the mucoperiosteal flaps were repositioned coronally and fixed with vertical or horizontal mattress sutures in such a way as to ensure a non-submerged healing procedure.

Post-operative care

Post-operative care consisted of rinsing with a 0.2% chlorhexidine digluconate solution (Corsodyl®, GlaxoSmithKline Consumer Healthcare, Bühl, Germany) twice a day for 2 weeks. The sutures were removed 10 days after the surgery. Recall appointments were scheduled every second week during the first 2 months after surgery and monthly following the rest of the observation period. Neither probing nor subgingival instrumentation was performed during the first 6 months after the surgery. A supragingival professional implant/tooth cleaning and reinforcement of oral hygiene were performed at 4, 12 and 24 weeks after treatment.

Results

Surgical defect examination revealed that all implants in the test and control groups exhibited a semi-/or circumferential bone loss without dehiscence or fenestration of the adjacent vestibular and oral alveolar bone. However, in all cases, semi-/or circumferential bone loss was also associated with a horizontal loss of the supporting alveolar bone. The configuration of the defects is summarized in Table 3.

The post-operative healing was considered as generally uneventful. Minor complications were related to usual post-operative swelling and occurred within the first days after surgery in both groups. Neither allergic reactions nor suppuration or abscesses were observed in any of the patients. However, NHA seemed to compromise initial adhesion of the mucoperiosteal flaps in all patients. This was particularly observed within the first 10 days after surgery. In contrast, the mucoperiosteal flap seemed to be well attached over BDX+BG.

The mean PI and BOP for each of the groups at baseline and after 6 months are summarized in Table 4. In both groups, the mean PI values remained low throughout the study period. In both groups, the mean BOP scores improved compared with baseline. The mean PD, GR and CAL in both groups at baseline and after 6 months are summarized in Table 4. In particular, at 6 months after therapy, the test group showed a reduction in the mean PD from 7.0 ± 0.6 to 4.9 ± 0.6 mm and a change in the mean CAL from 7.5 ± 0.8 to 5.7 ± 1.0 mm. In the control group, the mean PD was reduced from 7.1 ± 0.8 to 4.5 ± 0.7 mm and the mean CAL changed from 7.5 ± 1.0 to 5.2 ± 0.8 mm.

The frequency distribution of CAL gains in both treatment groups is shown

Table 4. Clinical parameters (mean ± SD) at baseline and after 6 months ($n = 11$ patients in each group)

	Baseline	6 Months	Difference
Plaque index			
Test	0.7 ± 0.5	0.6 ± 0.5	0.1 ± 0.5
Control	0.8 ± 0.4	0.7 ± 0.5	0.1 ± 0.3
Bleeding on probing (%)			
Test	82	30	52
Control	78	28	50
Probing depth (mm)			
Test	7.0 ± 0.6	4.9 ± 0.6	2.1 ± 0.5
Control	7.1 ± 0.8	4.5 ± 0.7	2.6 ± 0.4
Gingival recession (mm)			
Test	0.5 ± 0.5	0.8 ± 0.5	0.3 ± 0.2
Control	0.4 ± 0.3	0.7 ± 0.6	0.3 ± 0.2
Clinical attachment level (mm)			
Test	7.5 ± 0.8	5.7 ± 1.0	1.8 ± 0.6
Control	7.5 ± 1.0	5.2 ± 0.8	2.3 ± 0.6

Table 5. Frequency distribution of CAL gain in the test and control groups ($n = 11$ patients in each group)

CAL gain (mm)	Test		Control	
	No	%	No	%
1			1	9.1
2	9	81.8	4	36.4
3	2	18.2	6	54.5

CAL, clinical attachment loss.

in Table 5. In particular, in the test group, 18.2% of the sites ($n = 2$ defects) gained at least 3 mm of CAL. In contrast, a CAL gain of 3 mm was measured in six defects (54.5%) in the control group (Table 5).

In both groups, radiological observation revealed a decreased translucency within the intrabony component of the respective peri-implant bone defects. In particular, after 6 months of healing, both NHA and BDX+BG seemed to be organized by a dense and compact hard tissue-like structure exhibiting a quality similar to that of the adjacent parent alveolar bone (Fig. 3). However, one implant of the test group revealed no or merely a slight decrease in radiolucency at the mesial aspect of the defect (Fig. 4).

Discussion

The results of the present case series have indicated that treatment of intrabony peri-implantitis defects with both NHA and BDX+BG resulted in clinically important reductions in PD and gains of CAL at 6 months after surgery. Even though the clinical results may also be supported by a decreased radiotranslucency within the intrabony component of respective peri-implant bone defects in both groups, it must be pointed out that the radiographs were not standardized. Furthermore, it should be emphasized that the study does not have the statistical power to rule out the possibility of a difference between the two groups. Further studies, with a much higher number of patients and defects, would be needed to detect an eventual difference between the treatments (Gunsolley et al. 1998). From a clinical point of view, however, it must be pointed out that NHA seemed to compromise initial adhesion of the mucoperiosteal flaps in all patients. In contrast, the mucoperiosteal flaps were well attached over BDX+BG. This observation might be due to the specific physicochemical properties noted for BG. Indeed, native collagen has been reported to promote early wound stabilization by its chemotactic properties to attract fibroblasts (Postlethwaite et al. 1978). This is also in agreement with the results of recent experimental studies in rats, which have shown that BG exhibited the highest tissue integration among all barrier membranes investigated (Rothamel et al. 2005, Schwarz et al. 2006b). In contrast, it is impossible to estimate to what extent the specific physicochemical properties of NHA might have compromised fibroblast attachment and subsequently the adhesion of the mucoperiosteal flap. Another problem encountered during the surgical procedure was the low consistency of NHA, which in turn might result in a poor resistance to collapse of the mucoperiosteal flap into the intrabony defect, allowing undesirable cell types to enter the secluded wound area. This collapse may be prevented by means of implantation of additional bone grafts or bone graft substitutes into the defect to support NHA, preserving its original position. Further experimental studies are needed in order to clarify these issues. When interpreting the present results, it has to be noted that the mean CAL gain as observed 6 months post-operatively was 1.8 ± 0.6 mm in the NHA group and 2.3 ± 0.6 mm in the BDX+BG group. In this context, it needs to be pointed out that these are the first data evaluating the use of both bone grafting materials for non-submerged healing of intrabony peri-implantitis defects in humans. Therefore, a comparison with other studies is not possible. However, the clinical improvements noted in both groups seemed to be within the range of other regenerative treatment procedures reported in previous studies (Hämmerle et al. 1995, Mattout et al. 1995, Behneke et al. 2000, Haas et al. 2000, Khoury & Buchmann 2001). In particular, Haas et al. (2000) used autogenous bone (AB) graft particles covered with an e-PTFE membrane around 24 IMZ implants after implant surface decontamination using photosensitization by Toluidine blue and soft laser irradiation. After 9.5 months of submerged healing, radiographic evaluation demonstrated a mean bone gain of 2 mm, merely corresponding to 36% of the previous defect height. Similar results were also reported by Khoury & Buchmann (2001). After 6 months of non-submerged healing, the mean PD reduction was 1.5 mm for AB grafts alone, 1.3 mm for AB+BG and 1.5 mm for AB+e-PTFE. Bone gain varied between 1.9 and 2.8 mm after an observation period of 3 years. In this study, the implant surface was cleaned with chlorhexidine, citric acid and hydrogen peroxide. Even though several treatment approaches have indeed demonstrated beneficial clinical and radiological effects, the amount of documented bone regeneration and re-osseointegration, as observed histologically in animals, varied considerably (Ericsson et al. 1996, Persson et al. 1996, Hürzeler et al. 1997, Nociti et al. 2001b, Schou et al. 2003a–c, 2004). In most of these studies, the re-establishment of osseointegration has even been questioned (Schou et al. 2004). In parti-

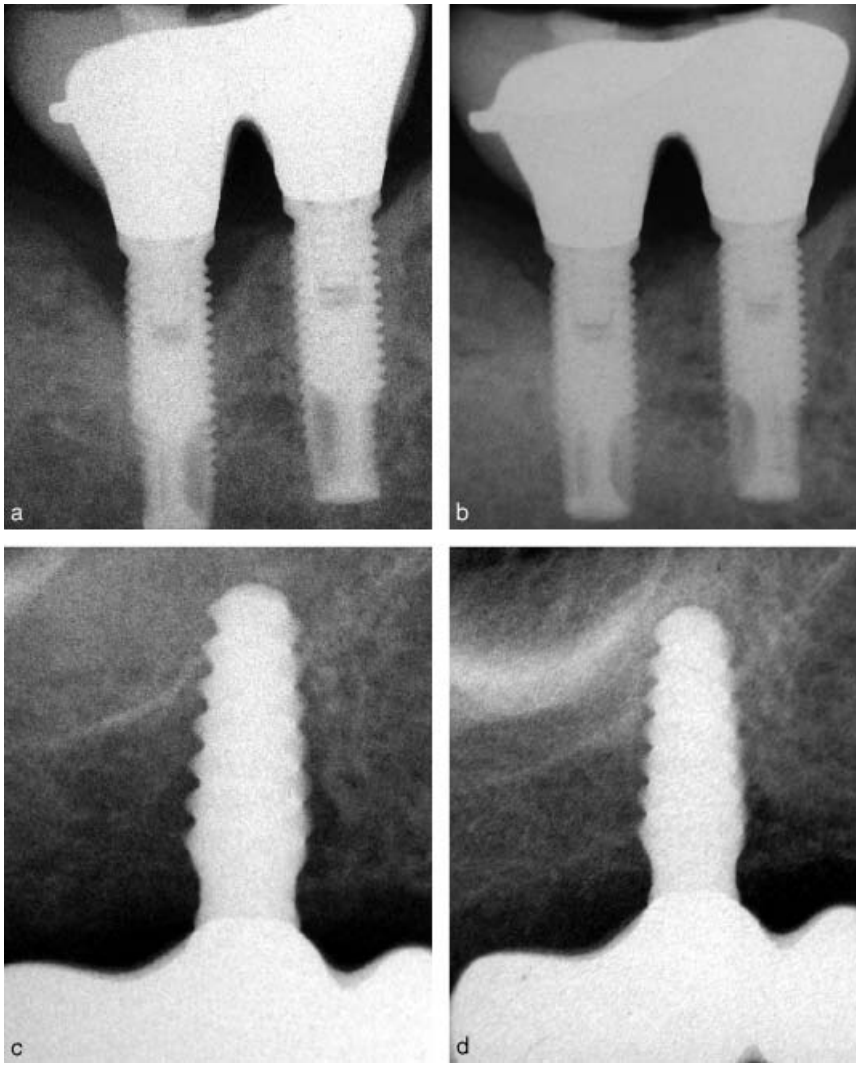

Fig. 3. (a)Radiograph immediately before application of bovine-derived xenograft in combination with a collagen membrane . (b) Post-operative radiograph at 6 months. (c)Radiograph immediately before application of nanocrystalline hydroxyapatite. (d) Post-operative radiograph at 6 months.

cular, Nociti et al. (2001b) evaluated either implant surface decontamination with an air-powder abrasive (DB) alone, DB+BDX+PTFE, DB+BDX+BG, DB+PTFE, DB+BG or DB+BDX for the treatment of ligature-induced peri-implantitis defects in dogs. After 3 months of submerged healing, histomorphometrical analysis did not reveal significant differences among the treatment groups regarding the percentage of new bone-to-implant contact (BIC), ranging from 26% to 31% (Nociti et al. 2001b). The clinical assessment of vertical bone fill (%) revealed the highest values for DB+BDX+BG (27.77 ± 14.07), followed by DB+BG (21.78 ± 16.19), DB+BXD (21.267 ± 6.87), DB+BDX+PTFE (19.57 ± 13.36), DB+PTFE (18.86 ± 10.63) and DB (14.03 ± 5.6). The differences between the groups were statistically not significant (Nociti et al. 2001a). Accordingly, it might be concluded that the combination of grafting materials and a membrane seems to be preferable in the surgical treatment of intrabony peri-implantitis defects. In this context, it must also be emphasized that membrane exposure has been reported to be a frequent complication, particularly following application of e-PTFE, ranging from 13% to 38% (Schou et al. 2003a–c). However, the present study failed to reveal any membrane exposures for BG, outlining that this type of native collagen seemed to be well integrated in the peri-implant soft tissues. To the best of our knowledge, there are currently no histologic data evaluating re-osseointegration at failing implants following the application of NHA. However, previous results of an experimental study in pigs revealed a complete resorption of the material at 12 weeks (Thorwarth et al. 2005). In this study, critical size calvarial defects were prepared and filled with either NHA, AB or NHA+AB (25%). Microradiography indicated mineralization rates in the two bone substitute groups that were not significantly lower than those found in the AB group (Thorwarth et al. 2005). Similar results were also reported by Chris Arts et al. (2006), as NHA was mostly osseous-integrated after 8 weeks. Furthermore, it was observed that non-osseous-integrated NHA remnants were actively being resorbed by osteoclasts (Chris Arts et al. 2006). When interpreting these results, however, it must be kept in mind that the acute-type defects involved in these studies might not necessarily represent the real situation encountered in a chronic, plaque-infected peri-implantitis defect. Indeed, histological studies in non-human primates have shown that in acute defect models approximately 50– 70% spontaneous regeneration can be expected, which in turn may lead to difficulties in interpreting the results (Caton et al. 1994).

Furthermore, it has to be pointed out that it is still unknown to what extent an implant surface previously exposed to bacterial plaque biofilm formation may serve as a sufficient base to establish new BIC following decontamination. Recent studies have demonstrated that plaque biofilms may alter the surface characteristics of titanium implants. It was presumed that bacterial contamination of a titanium surface may affect its dioxide layer, resulting in a lower surface energy and subsequently reduced tissue integration (Baier & Meyer 1988, Sennerby & Lekholm 1993). Accordingly, it must be queried to what extent the CAL gains obtained following implant surface decontamination using plastic curettes and irrigation with sterile saline followed by the application of NHA or BDX+BG represents true re-osseointegration rather than defect fill without new connective tissue attachment. Another important factor that was demonstrated to influence re-osseointegration strongly after treatment of peri-implantitis defects is the surface characteristic of the implant (Persson et al. 2001). Accordingly, the variety of

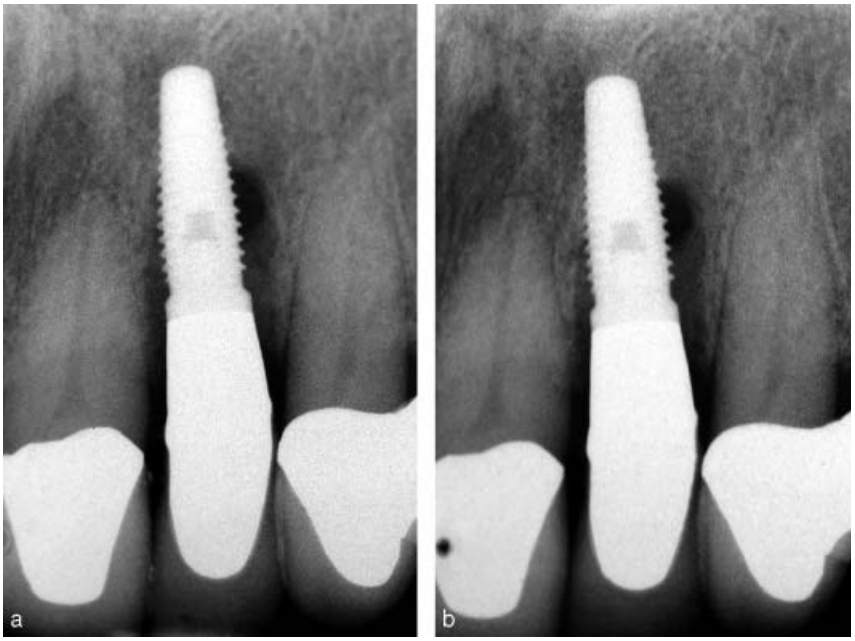

Fig. 4. (a) Radiograph immediately before application of nanocrystalline hydroxyapatite. (b) Post-operative radiograph at 6 months. There was no or merely a slight decrease in radiolucency observed at the mesial aspect of the defect.

different implant types and surface topographies may complicate a generalization of the present results.

Within the limits of the present case series, it can be concluded that at 6 months after surgery both therapies resulted in clinically important PD reductions and CAL gains.

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Clinical Relevance

Scientific rationale for the study: The clinical application of a nanocrystalline hydroxyapatite (NHA) or a bovine-derived xenograft in combination with a collagen membrane (BDX+BG) might improve healing of intrabony peri-implantitis defects.

Principal findings: The present results have indicated that both treatment procedures resulted in clinically important reductions in PD and gains of CAL at 6 months after surgery. However, NHA seemed to compromise initial adhesion of the mucoperiosteal flaps in all patients.

Practical implications: Both treatment procedures might improve healing of intrabony peri-implantitis defects at 6 months after surgery.